Fragmentation

The natural variation of biological communities across a landscape, often referred to as "natural patchiness," has always been a normal part of the environment. At the time of Euro-American settlement, the natural landscape of Wisconsin was broken up into wetlands, prairies, forests, lakes, and streams, all occurring in numerous patches of varying sizes. Some species, such as prairie chickens, thrived only on very large patches of suitable habitat. Others were more successful at the interface edge between plant communities and took advantage of two or more habitat types—for example, the white-tailed deer which uses forest, brushland, and prairie edges.

Many animal species need a high degree of "patchiness" because their life requirements are met by using different habitats at different times. Others, such as grassland birds and interior forest songbird species, are favored by relatively large, continuous habitats of similar vegetation. More subtle differences in soil, microclimate, moisture level, slope, and aspect permit plants to thrive in one area and not another. For example, the northern forest ecosystem includes numerous communities representing a range of successional stages as well as natural patches of oak, aspen, balsam fir, and tag alder, which under natural conditions gradually blend one into another. This "patchiness" may often protect plants from catastrophes such as disease, insect outbreaks, and fire.

Natural landscapes gradually merge one habitat type with another or leave corridors or ways for animals to move and still stay in their preferred habitat. Fragmentation is the breaking up of large and continuous ecosystems, communities, and habitats into smaller areas surrounded by altered or disturbed land or aquatic substrate. Fragmentation eliminates corridors and causes the abrupt meeting of different habitat types. In Wisconsin human activity has greatly fragmented the landscape, producing changes that are different from natural landscape heterogeneity or patchiness. For example, during Euro-American settlement the northern forests were logged and many areas were burned, leaving only scattered "islands" of forest remaining. These disturbances in the north occurred within a 50 year time period. After that time, the land-use pattern remained "undeveloped" in character and the land progressively grew back to forest. As agriculture and urbanization grew in southern Wisconsin, the southern forests, prairies, and wetlands were broken into increasingly smaller and more isolated fragments that remain today. Roads, sewer, and utility corridors; dams; residential, commercial, and industrial development;

In order to observe fragmentation of biological communities or ecosystems, we look at the pattern of fragments on the landscape, their sizes and proximity to one another, and the types of edge that define them.

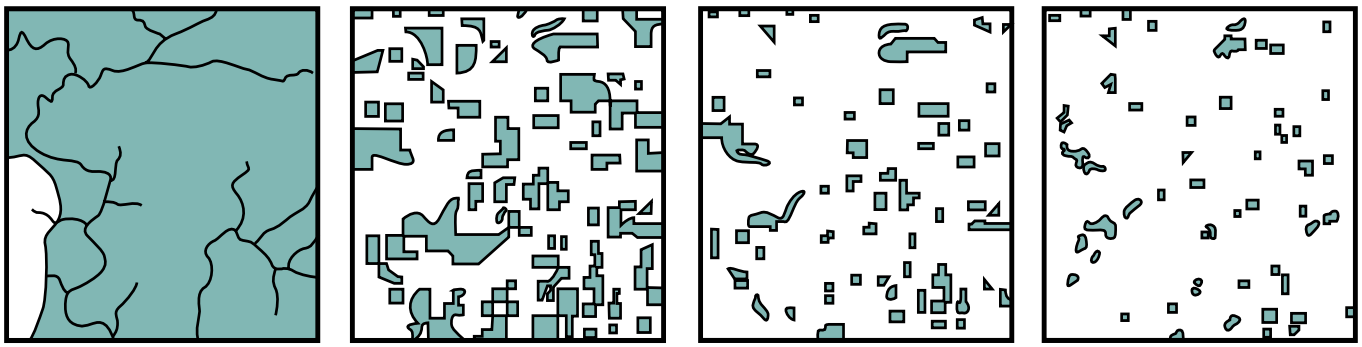

Figure 6

Changes in a wooded area of Cadiz Township, Green County, Wisconsin, during the period of Euro-American settlement. The shaded areas represent land remaining in, or reverting to, forest. This fragmented landscape is likely to exhibit effects from changes in the amount of edge, reduced size of fragments, and isolation of fragments. From Curtis (1956) with permission of the University of Chicago Press.

and land clearing and conversion continue to contribute to fragmentation in both the north and the south. Some traditional resource management practices have also contributed to fragmentation.

Many species continue to do well in these artificially segmented landscapes. Some, such as white-tailed deer, are even more successful than they were historically. However, many species of plants and animals lose ground as a result of increased fragmentation. Fragmentation generally results in three types of change: fragment size reduction, increased isolation of fragments, and increased edge-to-interior ratios (Fig. 6).

Size Effects

As the size of a particular fragment becomes smaller and smaller, more and more species disappear from it. For example, very large blocks of prairie historically contained more than 400 vascular plant species and a multitude of animal species including microfauna, insects, herptiles, birds, and mammals. As the prairies were broken up, large ungulates such as bison and large predators such as wolves quickly disappeared. As fragmentation continued, some plant species disappeared and many others became rare. Now many are in serious decline.

The *size effects* of fragmentation are particularly noticeable in the southern and west-central two-thirds of the state. Here major ecosystems (grasslands, savannas, and southern forest) were reduced in size and severely fragmented by agriculture and by urban and rural residential development. Many remnants of these once-expansive ecosystems are represented by community fragments too small to support viable populations of many species. For example, most species of the grassland bird guild are in decline, as are reptiles and amphibians. The ornate box turtle requires a minimum of 250 acres of prime sand barrens habitat to sustain a viable population, but only three or four areas of this habitat size and quality remain.

In the north, communities and ecosystems historically dependent on fire, e.g., the oak and pine barrens, have been fragmented and diminished in size by forest encroachment. Populations of species such as sharp-tailed grouse, which depend on these open areas, continue to decline across their historic range due to loss of barrens and other open habitat.

Isolation

Isolation of habitat patches occurs as the landscape becomes progressively fragmented. Areas of the same type become isolated, not only by distance but by hostile intervening environment, putting plants and animals without adaptations for long-range movement at a severe disadvantage. The inability of a species to move between habitat patches leads to loss of genetic viability and diversity and can ultimately lead to elimination of that species within that fragmented habitat. As the intervening environment becomes increasingly hostile even the more mobile species have their movement between habitat islands thwarted. Today, many community and ecosystem fragments are so far apart and so reduced in size that many animals fail to maintain populations. The communities become closed systems subject to catastrophic change from events such as disease, drought, wind storm, or floods.

Some of the most prominent examples of isolation resulting from habitat or community fragmentation can be found in what is left of the prairie ecosystem. This ecosystem is now severely reduced to small isolated fragments scattered about in a "sea" of agricultural and other lands inhospitable to many of the prairie species, especially invertebrates and plants. Recent survey work in Illinois suggests that at least 15% of what is left of prairie insects are now restricted to prairie remnants. These remnants range in size from two to 1,000 acres; most are in the 2-40 acres in size. As much as 30%-40% of our prairie plants may also be remnant-restricted. Without connecting corridors or "stepping-stones" of close enough proximity and large

enough size, many of these species populations will remain permanently isolated and thus subject to inbreeding, continued decline in numbers, and eventual elimination from that patch of habitat.

Aquatic ecosystems are also subject to isolation. All of Wisconsin's large rivers, most of its medium-sized rivers, and many smaller streams have been fragmented by dams. Fragmentation causes streams to become a series of modified ecosystems which no longer represent the native ecosystem in structure, function, and composition. Lake shores have also been fragmented by sand blankets and vegetation removal associated with shoreline developments. Dams prevent fish from reaching upstream spawning grounds, but there are other, more subtle effects of dams. For example, damming frequently isolates mollusks from the fish that host their larval stages; mollusks unable to complete their life cycle because of this isolation are eventually eliminated from the stream. For other species, populations are diminished when individuals succumb to siltation and other effects of damming.

Edge Effects

Edge effects occur near the interface of two or more different habitat types. Edge effects are beneficial for many plant and animal species, since edge allows them to take advantage of two or more habitat types for their survival. However, many other species are negatively affected by too much edge. The concentration of many species near edges causes increased competition, predation, and parasitism. For example, waterfowl nesting near the edges of grassy fields experience high nest predation, as do some songbirds nesting near forest-field edges. Or, some plants may disappear from previously suitable interior habitat when a new edge changes the micro-climate. As community or ecosystem islands get smaller or more disturbed, they become less and less viable for interior plants and animals. In effect they become all edge.

Encroachment of exotic species is closely associated with edge dynamics. In forests, many exotics gain entry to interiors by first getting established in the disturbance zone associated with human-caused disruption. Interior edge, which is more common in the north, is caused by logging, agriculture, blowdowns from wind storms, fire, and residential and commercial development, and takes on the same form and effect as exterior edge. Area- and edge-sensitive interior species are especially vulnerable to interior edge conditions.

Corridors for roads, power transmission lines, and pipelines create linear edge throughout the north, while in the south, these corridors sometimes bisect woodlots, wetlands, and grasslands. These corridors are havens for edge species and allow for penetration of species into otherwise continuous communities and ecosystems.

Environmental Pollution

Environmental pollution is the human-induced addition of many types of substances to air, land, and water in quantities and/or at rates that harm organisms, habitats, communities, ecosystems, or human health. Examples are nutrients, heavy metals, organic compounds, and sediments. Pollution may change the physical, chemical, or biological characteristics of air, water, or land, thus affecting the health, survival, or activities of living organisms in a variety of detrimental ways, including impacts on genetic, species, community, and ecosystem diversity.

Any Department policies relating to biological diversity need to consider the effects of pollution and the efforts required to manage resources that have been adversely affected by pollution. The following examples illustrate some of these effects as they relate to water, air, and land resources.

Pollution may change the physical, chemical, or biological characteristics of air, water, or land—affecting the health, survival, or activities of organisms and contributing to the forces that simplify and fragment communities and ecosystems.

Adverse Impacts to Surface and Ground Water Systems

Poorly managed construction sites and bare fields allow soil to wash off the land in runoff. This sediment can smother gravel riffles in a stream, destroying the habitat for aquatic invertebrates and